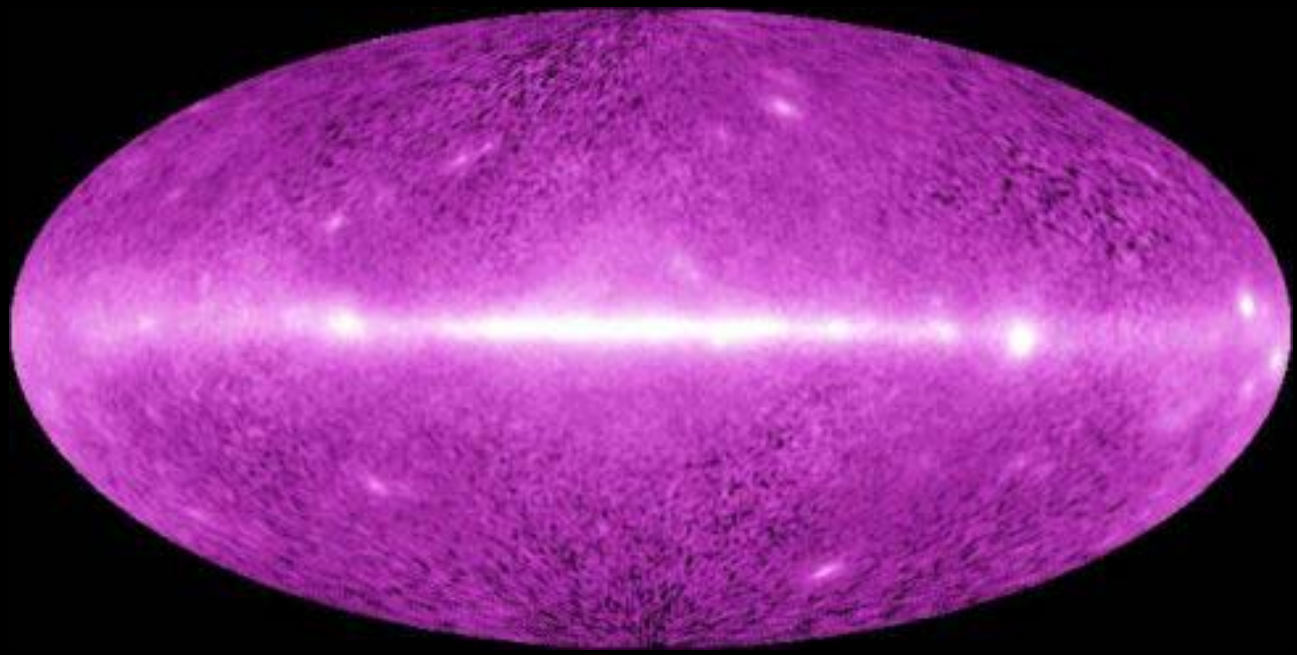
Angular features in the diffuse γ-rays: Signatures of dark matter

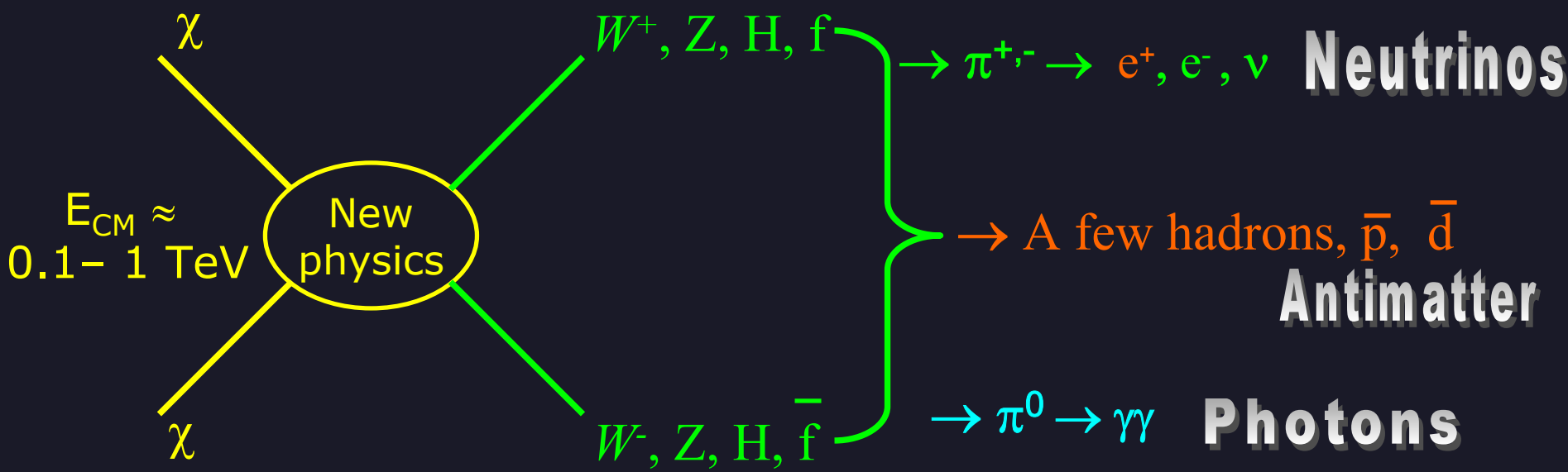


Pasquale D. Serpico, Center for Particle Astrophysics

Fermilab

Argonne National Laboratory – 13 April 2007

Indirect detection of dark matter



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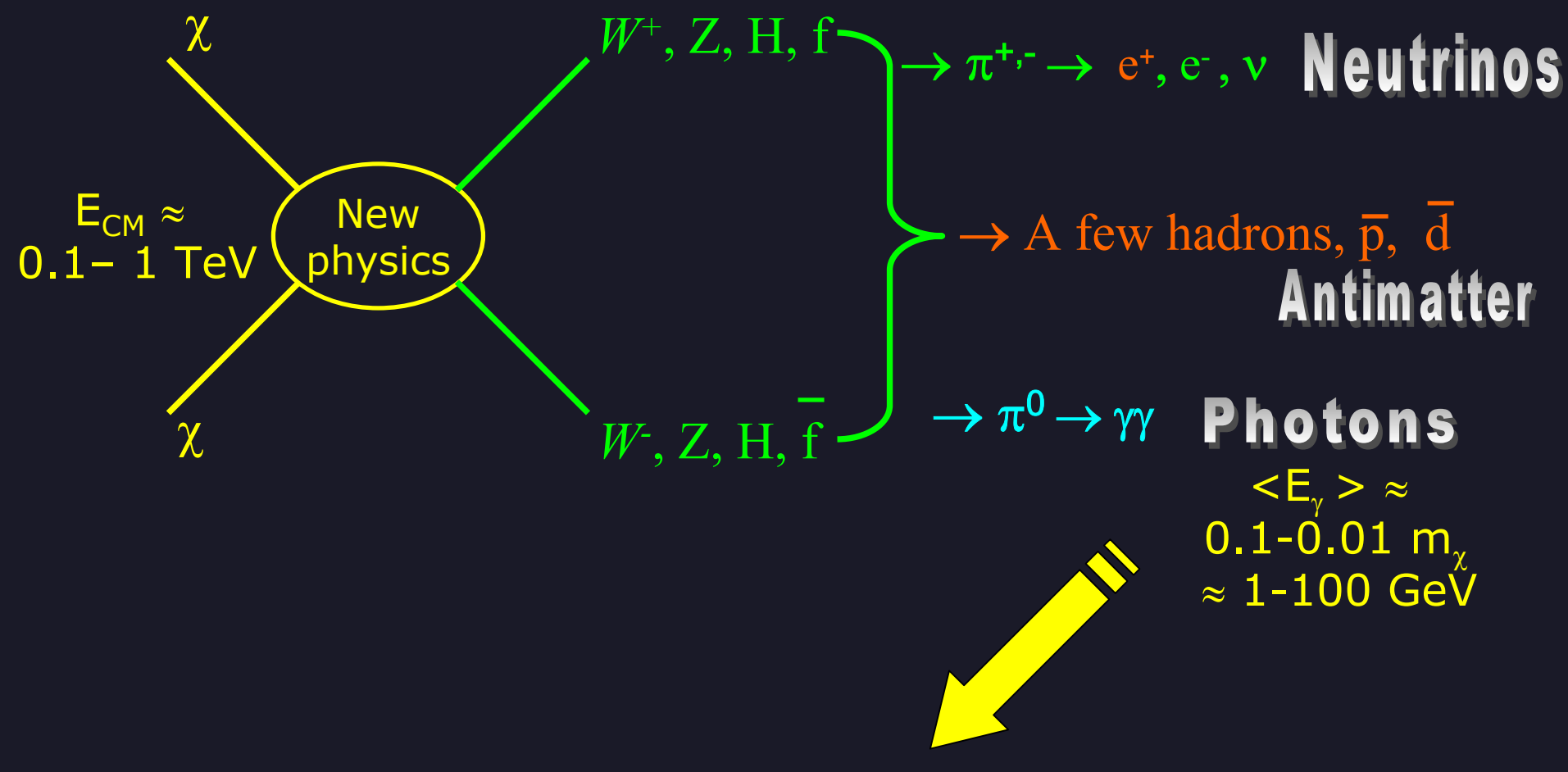

Where to look for Gammas from DM?

Target	*Advantage*	*Challenges*
Spectral line E= m_χ anywhere	Smoking gun	Loop process, suppressed
Galactic center	High intensity	DM profile, astrophysical foregrounds
Satellites, μ-halos…	Low background	Low statistics, DM profile
Diffuse galactic & extragalactic	High statistics	Cosmological uncertainty, astrophysical foregrounds

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angular *AND* energy information

Possible Deterministic Anisotropies

- ✓ Extragalactic Angular features
  - ❑ Correlations with the local LSS

A.Cuoco, S.Hannestad, T. Haugbolle, G. Miele, PS & H. Tu, astro-ph/0612559

  - ❑ Motion of the Sun wrt the CMB: Cosmic Compton-Getting effect

M. Kachelrieβ & PS, Phys. Lett. B 640, 225 (2006) [astro-ph/0605462]

- ✓ Galactic Angular features
  - ❑ Offset position of the Sun in the halo
  - ❑ Motion of the Sun wrt the Halo: Compton-Getting effect

D.Hooper and PS, astro-ph/0702328

- ➢ Statistical Angular features may be of interest, too!

S. Ando & E. Komatsu Phys. Rev. D 73 023521 (2006) [astro-ph/0512217]

S. Ando et al. Phys. Rev. D 75 063519 (2007) [astro-ph/0612467]

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The LAT instrument on GLAST will detect millions of diffuse photons!

It is interesting to consider even small (but robust) signatures!

Compton-Getting effect

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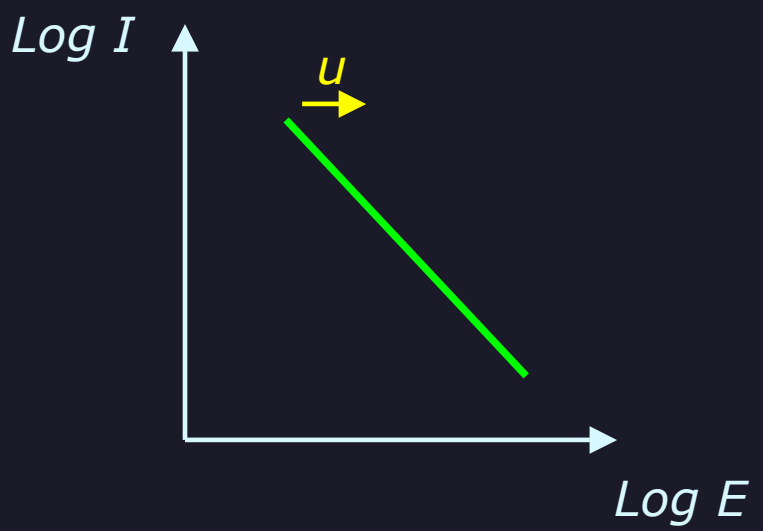
(Received April 12, 1935)



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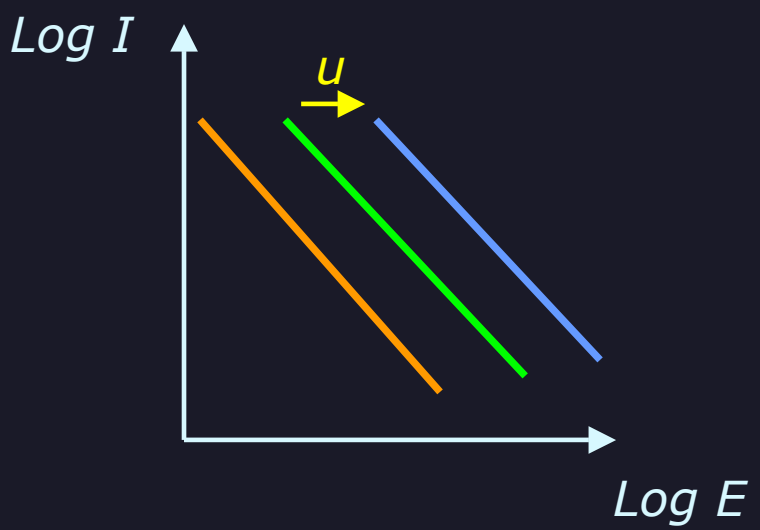

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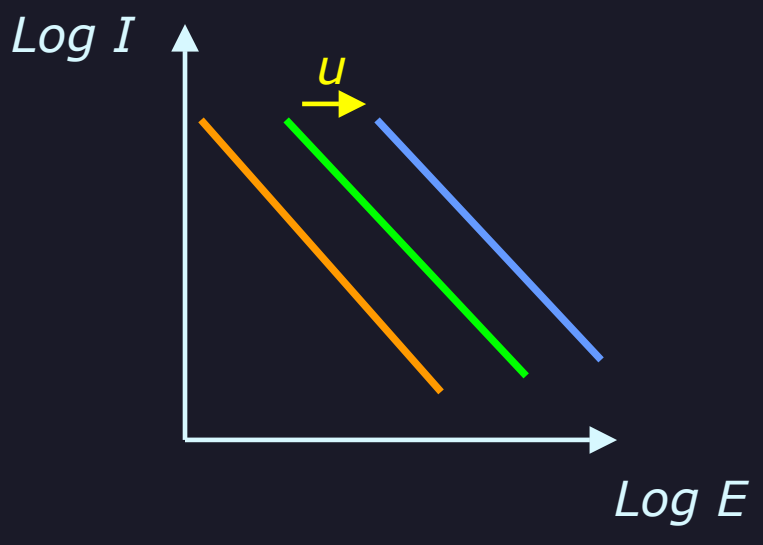
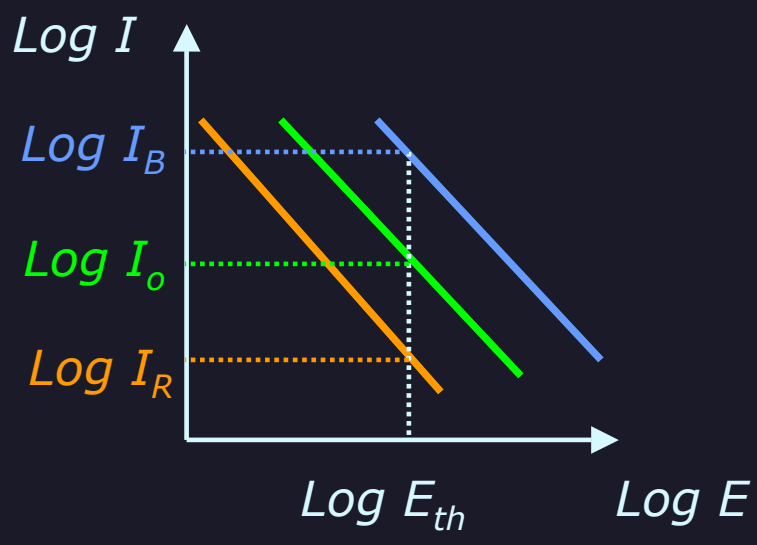
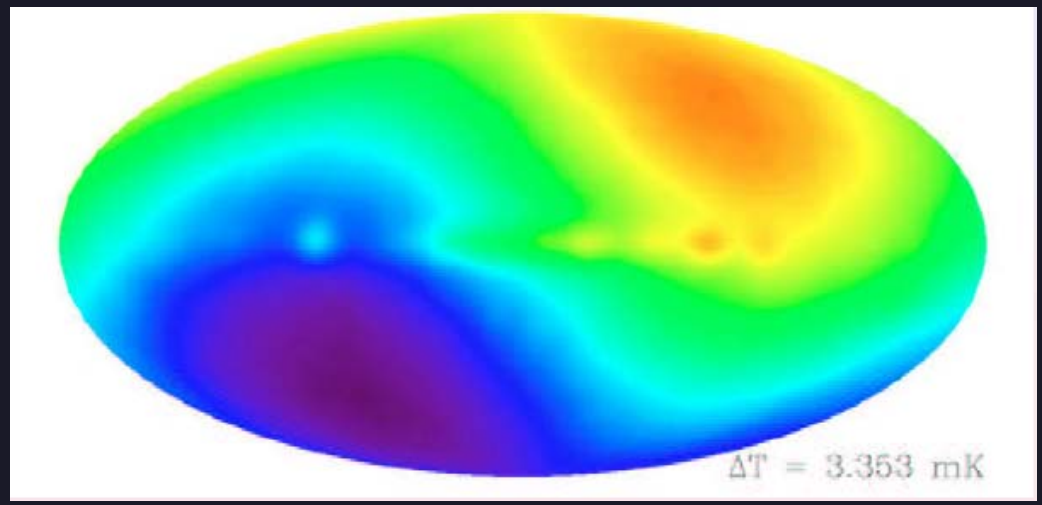




Cosmological Compton-Getting Effect

✓ The solar system is moving (u=368 km/s) with respect to the cosmological rest frame, as indicated by the CMB dipole



✓ As long as we collect γ's from a large number of sources at cosmological distance, sources are on average at rest

A dipole anisotropy should be visible in the HE sky with amplitude

$$[I(E)=E^2 f(E)]$$

$$A_{CCG} = \frac{I_{max}-I_{min}}{I_{max}+I_{min}} = u/c\ (2-\ d\ ln\ I/d\ ln\ E) = 0.5\%$$

CCG effect for γ's

✓ A detection of the CCG effect is well within the reach of GLAST (with the EGRET flux, O(10^6) useful γ *per year* at E>GeV)
The signature has been detected in the X-ray background

S.P. Boughn, et al. ApJ 580, 672 (2002) [astro-ph/0208153]

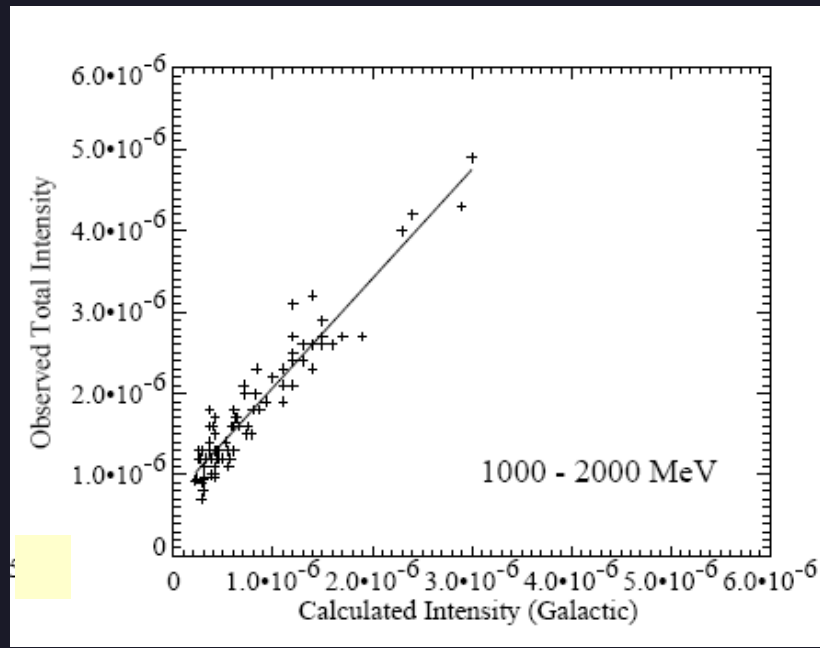
C.A. Scharf et al ApJ 544, 49 (2000) [astro-ph/9908187]

✓ CCG effect would allow one to extract the truly extragalactic fraction of the diffuse γ, basically in a model independent way

✓ The method is complementary to the traditional one

$$I_{tot}(E,b,l)=A+B\, I_{Gal}(E,b,l)$$

✓ Not Peculiar of DM, yet a bound or detection would constrain DM properties



Compton-Getting effect & Galactic DM

✓ The baryonic disk of the Galaxy is suppported against radial collapse by its angular momentum

✓ The dark halo is supported by random velocity

(collisionless pressure)

✓ The disk rotates into the rest frame of the DM halo with velocity u=220 km/s. A CG dipole with amplitude of about 0.3% is expected if DM dominates the diffuse flux

✓ Note that this is a DM-peculiar effect, since astrophysical contamination from the disk would be co-rotating with us

Conclusions

- Unveiling the nature of DM is one of the greatest unresolved mysteries of astrophysics and cosmology, and one of the few arguments in favor of physics beyond the standard model

- In most models, DM may be detectable in one or more ways (direct, indirect or collider searches). One promising way is via the gamma rays produced via DM annihilation

- Many candidate sources exist in the Universe. Diffuse fluxes, besides spectral features, have peculiar angular shapes. The large scale ones are robust and deterministic. If the emission is at least at the few percent of the overall diffuse flux, there are good chances of DM detection.